Space Technology Research Grants

Optimizing a Two-Step Laser Time-of-Flight Mass Spectrometer for In Situ Astrobiology Investigations

Completed Technology Project (2013 - 2016)

Project Introduction

The search for the presence of extant or extinct life on any planetary surface outside of Earth's biosphere begins with the identification and characterization of biosignatures within geologic samples. I will identify the spectral characteristics of amino acids and other chains of basic organic compounds essential to life on Earth for use as analogs for the identification of extraterrestrial biosignatures. There are relatively few geologic samples of other planetary surfaces available to us on Earth, requiring most data acquisition to be performed in situ. Cost and engineering constraints placed on lander-based scientific instruments require these instruments to be compact, low-power, and environmentally versatile. I propose to test and optimize a two-step laser desorption time-of-flight mass spectrometer (L2MS) for organic and biosignature identification. I will test several desorption and ionization laser configurations on a suite of organic and inorganic sample classes to build the phase space of the optimal L2MS laser configurations. I will also apply several statistical algorithms to the data obtained with the L2MS and existing, complementary instrumentation available at NMSU, including IR and UV reflectance spectrometers and a laser-induced breakdown spectroscopy (LIBS) instrument to quantify the effectiveness of these instruments as biomarker identification tools and exploit the unique mineralogical and astrobiological results each instrument contributes. The L2MS operates by first desorbing material on a sample surface using a pulsed IR laser, and subsequently ionizing the analyte using a pulsed UV laser directed orthogonally to the IR laser. The desorbing laser pulse generates a neutral plume of analyte from a solid sample. After a tunable delay, the ionizing laser pulse intersects the neutral plume above the sample surface. When the laser energy exceeds a threshold value, ions are generated in the plume and accelerated into the instrument for mass analysis. I will determine the ideal desorbing and ionizing laser configurations by finding the optimal laser wavelengths, timing between desorption and ionization of the neutral plume, and geometric position of the ionizing laser relative to the desorption laser. The optimized L2MS configuration will be dependent on the molecular structure of the organic sample, and in order to reduce excessive fragmentation, I will determine the optimal configuration for several sample classes including synthetic PAHs, amino acids, nucleobases, peptides, and naturally occurring organics within field samples. The NASA Science Instruments, Observatories, and Sensor Systems Roadmap requires technological advancements in biological detection and characterization to achieve a ppb sensitivity and an in situ characterization of organic materials, and advancing the aforementioned technologies will ensure NASA's continued leadership in these areas. The completion of this project will address these NASA technology and astrobiology roadmap objectives through the development and optimization of the L2MS instrument, exploring the detection capabilities of the L2MS on a broad, systematic sample suite, and determining how results from several spectrometer instruments can be used to inform the laser configuration of the L2MS. This high priority, innovative technology development will create new

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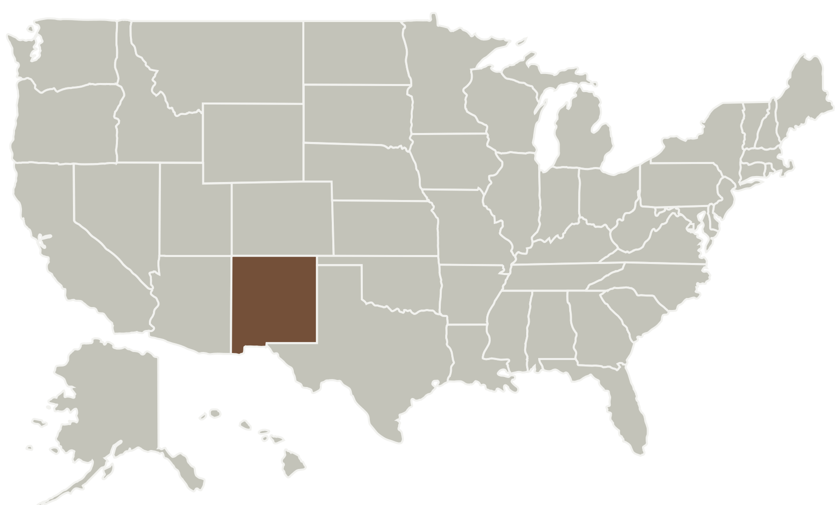
capabilities for future NASA missions.

Anticipated Benefits

The NASA Science Instruments, Observatories, and Sensor Systems Roadmap requires technological advancements in biological detection and characterization to achieve a ppb sensitivity and an in situ characterization of organic materials, and advancing the aforementioned technologies will ensure NASA's continued leadership in these areas. The completion of this project will address these NASA technology and astrobiology roadmap objectives through the development and optimization of the L2MS instrument, exploring the detection capabilities of the L2MS on a broad, systematic sample suite, and determining how results from several spectrometer instruments can be used to inform the laser configuration of the L2MS. This high priority, innovative technology development will create new capabilities for future NASA missions.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
New Mexico State University-Main Campus	Lead Organization	Academia Alaska Native and Native Hawaiian Serving Institutions (ANNH), Hispanic Serving Institutions (HSI)	Las Cruces, New Mexico

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

New Mexico State University-Main Campus

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Nancy J Chanover

Co-Investigator:

Kyle Uckert

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Primary U.S. Work Locations

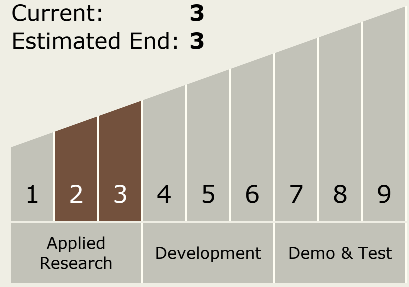
New Mexico

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - └ TX08.3 In-Situ Instruments and Sensors
    - └ TX08.3.2 Atomic and Molecular Species Assessment

Target Destinations

Outside the Solar System, Foundational Knowledge